WISCONSIN'S CHANGING CLIMATE:

IMPACTS AND ADAPTATION

The first report of the Wisconsin Initiative on Climate Change Impacts

2011

SUMMARY

Wisconsin's climate is changing. A wealth of temperature and precipitation data provide evidence that on average our state has become warmer and wetter over the past 60 years. Scientists project that the decades ahead will bring changes in climate much more profound than those already observed; in some cases those changes could occur more rapidly than plant or animal species can adapt. This first report from the Wisconsin Initiative on Climate Change Impacts (WICCI) seeks to identify the impacts of those changes as well as the strategies needed to adapt to them.

Historical temperature and precipitation patterns have varied widely across regions of the state, especially when seasonal differences are factored in. For instance, in the 1950-2006 period used in this report, **winter** temperatures increased significantly in northwestern Wisconsin, and these increases extended into the central part of the state. Springtime temperature increases also occurred in the same regions. During winter, nighttime minimum temperatures warmed at a faster rate than daytime maximum temperatures, and the number of very cold nights declined significantly. Northwestern and central Wisconsin experienced 14 to 21 fewer nights with temperatures below zero degrees Fahrenheit. Other areas of the state saw reductions in subzero nights of seven days or less.

During **summer** months, daytime maximum temperatures across the state changed little from 1950 through 2006, but nighttime minimum temperatures warmed significantly in the northwestern and central regions. Similarly, the number of days when temperatures exceeded 90º F did not increase throughout the state. Autumn temperatures did not warm statewide; northeastern and southwestern Wisconsin actually cooled slightly during the fall.

Precipitation also varied widely across the state, with localized drought in some northern regions and much wetter conditions in western and south central Wisconsin. Statewide, average annual precipitation increased by about 15 percent from 1950 through 2006. In some regions, including south central and western Wisconsin, annual precipitation increased by as much as seven inches. In areas of northern Wisconsin, however, declines of up to four inches were recorded.

Future projections of temperature and precipitation patterns for Wisconsin were created by University of Wisconsin-Madison climate scientists using 14 "downscaled" global circulation models. Their work indicates that **Wisconsin's warming trend will continue and increase considerably** in the decades ahead. By the middle of the century, statewide annual average temperatures are likely to warm by 6-7º F.

By mid-century, seasonal temperature increases (above current conditions) are projected to be greatest in winter, followed by spring and fall, then by summer. For example, wintertime temperatures are likely to increase by about 8º F, with slightly warmer temperature increases in northwestern Wisconsin. Summertime average temperatures are likely to rise 5-6º F statewide, with the greatest warming in northern Wisconsin. In addition to this warming, the number of summer days that exceed 90º F is projected to increase statewide. Southern and western regions of Wisconsin could see three or more weeks per year of these very hot days, while northern regions are likely to see an increase of about two weeks. A smaller increase in the number of hot days is projected for the areas along Lake Superior and for Wisconsin's "thumb" in Lake Michigan due to the cooling effect of the Great Lakes. Consistent with these warming trends, the number of winter nights below 0º F is projected to decrease significantly across the state by mid-century. A decline of about three weeks of these cold nights is expected in northern Wisconsin, with about one fewer week in the southeastern counties.

While our future precipitation patterns are more difficult to discern than temperature, the state is likely to continue its trend toward more precipitation overall, with the most probable increases in winter, spring and fall. Large storm events are also likely to increase in frequency during spring and fall. Statewide, the amount of precipitation that falls as rain rather than

snow during the winter is also projected to increase significantly, and freezing rain is more likely to occur.

Rising air temperatures, shifting precipitation patterns and increases in heavy rain events lead to a variety of secondary effects on our natural and built environments. These changes bring impacts at both broad and local levels, affecting the state as a whole as well as individual species of plants, fish and wildlife, and human communities.

The **quantity and quality of Wisconsin's water resources** are influenced by climate change. For example, we are seeing a decrease in the length of time that ice covers our lakes. A detailed examination of ice records for Lake Mendota in Dane County shows that the annual duration of ice cover has declined by about a month over the last 150 years. Water levels are higher in many areas due to increased precipitation but lower in the north due to a prolonged drought. With evapotranspiration rates projected to increase in the future, water levels in northern lakes and wetlands could decline further during future periods of drought, such as the droughts that have occurred periodically during the past century. More runoff from projected heavy seasonal rainfalls will likely increase sediment and nutrient inputs to lakes and wetlands, leading to more blue-green algal blooms in lakes and loss of biodiversity in wetlands. Changes in the timing and amount of rainfall influence groundwater recharge, and any decrease in groundwater recharge could be compounded by increased demand for irrigation due to an extended growing season, shifts in the timing of precipitation, and high temperatures or regional droughts.

Natural habitats respond to a changing climate in many ways, with impacts seen in wildlife, forests and plant communities. Plant hardiness zones are shifting; consequently, the ranges for many plant and animal species are expanding northward. An earlier onset of spring will disrupt relationships between plants and pollinators and could cue reproduction or other lifecycle events at non-ideal times. Species currently found in northern Wisconsin at the southern edge of their range may no longer be able to survive in the state, while more southerly species, including those not currently present in the state, will expand northward. Animals like the American marten, spruce grouse and snowshoe hare may disappear from Wisconsin. Boreal tree species such as black spruce, balsam fir and paper birch may no longer grow in the state by the end of century, resulting in a dramatic change in the tree composition of our northern forests. Due to slow dispersal rates or fragmented habitat, migration of certain species to fill these northern voids is not certain.

Rising stream temperatures, which result from rising air temperatures and other factors, will lead to reduced habitat for native brook trout that require cold water. Scientists project that if summer air temperatures rise by 5° F, brook trout habitat will decline by 95 percent across the state. However, a warming climate will benefit other species, including the gray squirrel, white-tailed deer, European starling and Canada goose, with potential negative impacts on the environment resulting from increases in their populations.

Lower soil moisture levels are another change related to increased temperatures and evapotranspiration rates. Reductions in soil moisture affect numerous amphibians across the state such as frogs and salamanders that need moist conditions to survive. All of these changes could reduce biodiversity in Wisconsin and weaken the resilience of many ecosystems.

Wisconsin's agriculture will also be affected by climate change. In general, research suggests that warming temperatures in spring and fall would help boost agricultural production by extending the growing season across the state. However, increased warming during the summer months could reduce yields of crops such as corn and soybeans, with studies suggesting that every 2° F of warming could decrease corn yields by 13 percent and soybean yields by 16 percent.

The projected precipitation trends of more annual rainfall and more intense storms heighten the potential for significant **soil erosion**. Most soil erosion occurs during the few heavy rainfall events that occur each season, and an increasing number of these storms are likely in our future. This is especially true during the spring months, when cultivated fields are mostly bare with little plant cover to reduce soil erosion. Without appropriate adaptation measures, future precipitation patterns could double soil erosion rates by 2050 compared to 1990 rates. The good news is that Wisconsin

farmers and natural resource managers have effective conservation practices at hand, and widespread implementation has the potential to counter the threat of soil loss from climate change.

Wisconsin's **coastal regions** face new challenges as reduced ice cover, declining lake levels and increasing wind strength over the Great Lakes will bring impacts including increased shoreline erosion and recession and an increase in the vulnerability of shoreline infrastructure. Coastal wetlands face increased sedimentation from runoff and flooding and greater threats from invasive species that take hold when an ecosystem is disrupted or warmed. Lake Michigan's average water levels are expected to decline by about a foot by the end of the century. However, both high and low water levels will continue to impact coastal wetlands, bluffs and beaches due to natural fluctuations in water levels that occur every few decades.

Climate change also affects **society and the built environment**. New or more severe public health challenges arise as heat waves become more frequent and climatic conditions boost air pollutants such as smog and particulate matter. In the Chicago area, not far from several southeastern Wisconsin counties, occurrences of ground-level ozone exceeding current air quality standards are expected to increase from the present average of about two days per summer to about 17 days per summer by the end of the century. Pollen production is increasing, as well. All of these air pollutants worsen asthma and other respiratory diseases.

Waterborne diseases may multiply because human pathogens are introduced into the environment when combined and sanitary sewers overflow as a result of heavy rainfall or groundwater infiltration exceeding the capacity of wastewater treatment systems. In many places, current infrastructure is not equipped to handle the projected increases in frequency of heavy storms and subsequent runoff. This increases the risk that stormwater management and drinking water systems will fail and flooding will damage bridges, roadways and urban areas.

Adapting to impacts requires us to take a comprehensive view of climate change in Wisconsin. Adaptation strategies presented in each chapter of this report illustrate alternative ways to avoid some of the worst outcomes and take advantage of benefits where possible. They are provided to help stakeholders take action to create resilience within natural and built environments, build capacity to make better decisions, improve the communication of climate science and projected impacts to stakeholders, and fill gaps in our knowledge of how natural and human systems respond to climate change.

As stakeholders determine which strategies will best achieve their goals, several **adaptation principles** may apply. These principles help identify which actions to implement first, the degree to which flexibility can be built into resource management practices, and whether some strategies will bring benefits regardless of how the climate continues to change. For example, they suggest that when vulnerability is high, it may be wiser to be safe rather than sorry. They remind us that variability in both time and space needs to be recognized; even within Wisconsin, changes and responses to impacts will differ across the state. Many place-based impacts present unique restrictions and circumstances for adaptation. For example, large cities and tribal lands cannot be moved to more favorable climates, and designated natural areas may no longer protect the species they were originally designed to protect.

This report is the first in a series that will provide an ongoing assessment of climate change impacts and adaptation strategies in Wisconsin. Even as we present this synthesis of the findings of the 15 contributing working groups, the groups continue to move forward with vulnerability assessments and identification of adaptation strategies, while WICCI continues to identify topics and areas in need of future attention.

If Wisconsin is to adapt successfully to current and future climate change, information about climate science, predicted impacts, types of adaptation strategies and means of implementing those strategies must reach local and state decision-makers. WICCI envisions a climate adaptation outreach model that supports managers of natural and human systems and other decision-makers in assessing vulnerabilities and evaluating risks from climate impacts. WICCI will

continue to engage Wisconsin academic institutions, state agencies, local governments, professional associations, businesses and other organizations in a process of identifying climate adaptation strategies. Outreach activities will also provide information on climate risk and adaptation to communities to support implementation of climate adaptation strategies. This report builds a foundation for long-term integration of climate risk education into Wisconsin's professional and community development efforts. To meet these objectives, WICCI will collaborate with existing education and outreach groups and support integration of information about climate impacts and adaptation into existing and new outreach programs.

An appendix includes the executive summaries of the technical, scientific working group reports, which are available in full on the Web at www.wicci.wisc.edu. The executive summaries contain the main findings of each working group along with key figures. Please see the full working group reports for information on methods, results and citations.

CHAPTER EIGHT

IMPLEMENTING

Principles for Adaptation

The Road to Implementation

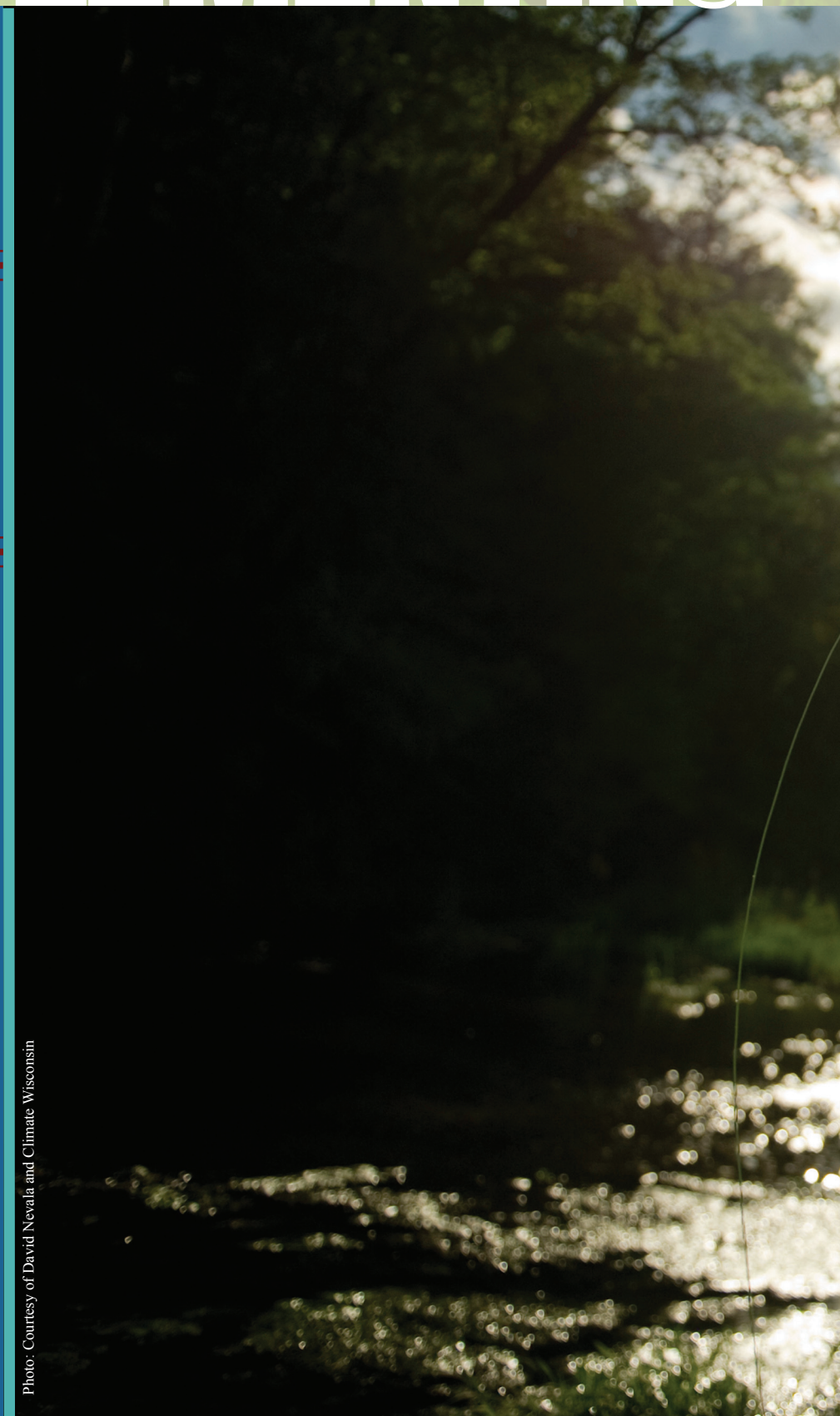
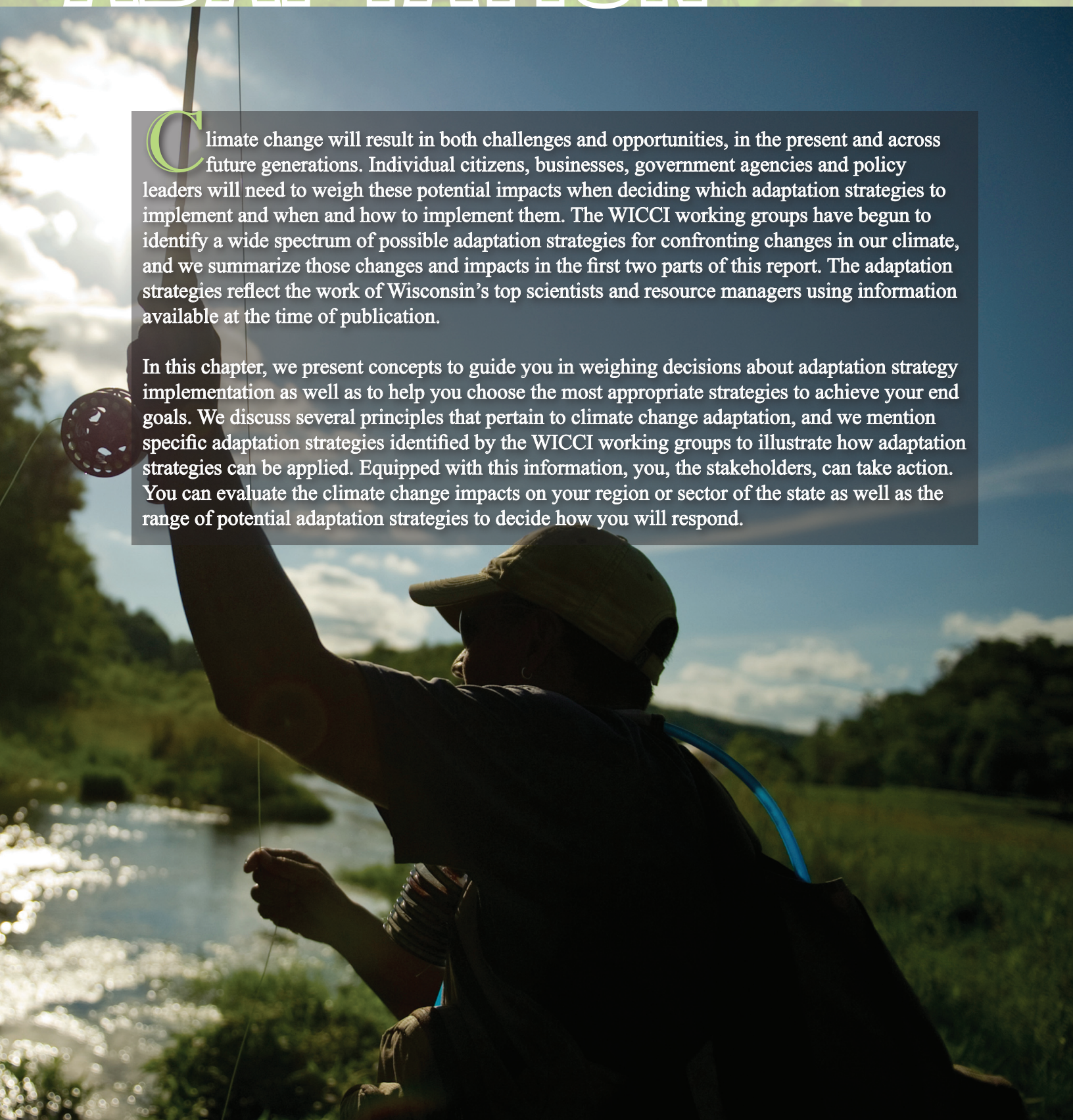


Photo: Courtesy of David Nevala and Climate Wisconsin

ADAPTATION



Climate change will result in both challenges and opportunities, in the present and across future generations. Individual citizens, businesses, government agencies and policy leaders will need to weigh these potential impacts when deciding which adaptation strategies to implement and when and how to implement them. The WICCI working groups have begun to identify a wide spectrum of possible adaptation strategies for confronting changes in our climate, and we summarize those changes and impacts in the first two parts of this report. The adaptation strategies reflect the work of Wisconsin's top scientists and resource managers using information available at the time of publication.

In this chapter, we present concepts to guide you in weighing decisions about adaptation strategy implementation as well as to help you choose the most appropriate strategies to achieve your end goals. We discuss several principles that pertain to climate change adaptation, and we mention specific adaptation strategies identified by the WICCI working groups to illustrate how adaptation strategies can be applied. Equipped with this information, you, the stakeholders, can take action. You can evaluate the climate change impacts on your region or sector of the state as well as the range of potential adaptation strategies to decide how you will respond.

Principles for Adaptation

Here we provide several principles for you to consider when making decisions about climate change adaptation and determining which actions are feasible to take now, later or not at all. Our intention is for these concepts to provide you with perspective in decision-making and guidance for implementation of appropriate adaptive actions.

Triage Approach

Determine which actions to implement first. The concept of triage involves directing resources to the issues and areas where strategic adaptation will be most effective. Adaptation can help us reduce risks and minimize impacts caused by climate change. We cannot, however, eliminate all risks and losses, even if we implement the most appropriate strategies. In some cases, investments in adaptation are unlikely to have significant returns. In other cases, effects of climate change will pose little risk and thus require nothing new to be implemented. Stakeholders will need to consider the value of possible adaptation strategies based on the vulnerability of a particular resource and the likelihood that a specific action will successfully address an identified concern. This triage approach will allow you to target limited resources most efficiently.

Adaptive Management

Build flexibility into management practices. Adaptive management offers a tool to help stakeholders

Photo: Darren Bush

make better decisions in the context of uncertainty as we continue to accumulate more information. Often characterized as "learning as we go" or "learning by doing," adaptive management provides a structured, iterative, decision-making process that can be used in the face of uncertainty with an aim of reducing that uncertainty over time. This approach involves ongoing, real-time learning and knowledge creation, both in a substantive sense and in terms of the adaptive process itself. The approach allows you to maintain **flexibility** in your decisions, knowing that uncertainties exist, and provides the latitude to change direction. In this way, decision-making can simultaneously maximize one or more resource objectives and, either passively or actively, accrue information needed to improve future management. Using adaptive management approaches will allow us to take **action** to improve progress towards desired outcomes. Such approaches also allow for new climate information to be incorporated as we move forward.

"No Regrets" Strategies

Choose strategies that increase resilience and provide benefits across all future climate scenarios. Implementation of some strategies will result in environmental or societal benefits no matter how the climate changes. We refer to these strategies as having no regrets. For example, protecting environmentally sensitive lands, encouraging water conservation and implementing polluted runoff controls makes sense under any climate scenario. These actions can build resilience without necessarily committing stakeholders and resources to novel future courses of action. We believe some of the best adaptation strategies will allow us to prepare for climate change by taking action now in ways that will not make adaptation in the future more difficult. The WICCI working groups identified actions that are intended to provide net environmental and social benefits under all future scenarios of climate change and impacts.

Precautionary Principle

Where vulnerability is high, it is better to be safe than sorry. Sometimes if we wait for certainty it is too late. The 1992 Earth Summit in Rio de Janiero proposed, "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." Given the breadth of likely climate change impacts in Wisconsin and the associated risks to the public and environment, we believe a precautionary approach should be taken by stakeholders even if some cause-and-effect relationships are not yet fully understood. Cases where the probability of risk is low but the vulnerability is very high suggest precautionary action should be taken. These "better safe than sorry" strategies can be modified later if new information suggests that no or minimal harm will result from a climate impact. The process of applying this precautionary principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including taking no action.

Adapting to Variability in a Changing Climate

Expect variability and work within it. Wisconsin's climate will continue to be highly variable across years and decades. Even though average temperatures have warmed and are projected to warm, and average

precipitation has increased and is projected to increase, there will still be unusually warm and cool years and unusually wet and dry years in the mix. It is essential to understand this variability in order to successfully implement adaptation strategies. For example, if brook trout disappear from a stream after a few unusually warm years, it may be possible to restock them to provide good fishing for a few cooler years before long-term warming trends cause them to die out again. If we had the ability to accurately project temperature variability between warm and cool over periods of a few years, our ability to manage threatened resources would be improved. The same logic is true for the operation of winter recreation facilities, crop-planting decisions and much of the annual planning done by individuals and groups. This highlights the need to improve our science: As we continue to monitor and better understand variability, we can continue to improve strategies for adapting.

Place-Based Considerations

Consider the restrictions and special circumstances of place-based impacts. Adaptation to climate change is important because our human and natural systems are fixed in location. All of Wisconsin's human and natural systems are "place-based" (for example, individual farms, municipalities, lakes and natural areas) and we know that climate change impacts vary spatially. We will need to consider these spatial relationships when adopting adaptation strategies. For example, climate change will affect the distribution of culturally important resources such as wild rice and walleye, but some of the Native American tribes who rely on these resources may not be able to follow those shifts in ranges because their reservation boundaries and off-reservation treaty rights are geographically fixed. People may – at a cost – decide to move out of a floodplain as floods become more prevalent, but industries and agriculture and their institutions are tied to place and will have to deal with the changing climate and its impacts. Place-conscious planning and place-based strategies can leverage our investments by focusing resources in targeted places and compounding the effects of well-coordinated action. Such approaches can also streamline otherwise redundant and disconnected programs.

Adaptation Complements Mitigation

Recognize the place of adaptation in the bigger picture. Adapting to climate change impacts is not a substitute for mitigation – the reduction of the rate at which greenhouse gases are emitted into the atmosphere. We can implement adaptation strategies that

help us adjust to and thrive in our natural and built environments as they are affected by climate change impacts at the same time as mitigation efforts are being enacted. The two goals can be pursued simultaneously, and in some cases, an adaptation strategy can achieve both adaptation and mitigation. For example, in Chapter 7: *People and Their Environment*, working groups suggest the need for programs and research on mass transit and vehicle technologies to both improve air quality and reduce ozone and greenhouse gases. We support and encourage the development and implementation of strategies that provide these co-benefits. As people better understand the impacts of climate change and how it affects air and water quality, our food systems and public health, they are likely to become more active in mitigation measures that address climate change at broader scales.

The Road to Implementation

Now that we have reviewed the main principles of adaptation, we turn to some specific adaptation strategies that WICCI working groups have recommended in order to highlight *toward what end* these actions work. We present the discussion here, consistent with the framework laid out in Chapter 2: *Understanding Adaptation* and the Adaptation Strategies boxes throughout the chapters in Part 2: *Impacts*. These examples generally illustrate ways in which adaptation strategies can address the climate change impacts on multiple resources. Readers can refer to the full working group reports (available at www.wicci.wisc.edu) for adaptation strategies for specific resources or locations.

In order to reduce risks from climate change, adaptation will require decisions that acknowledge both space and time. To be effective, some strategies will need to be implemented on a broad scale (statewide), while other actions can be implemented at a particular place (local or site-based). Similarly, some adaptation strategies can be implemented in the short term, but others will require planning and preparation that extend well into the future.

Taking Action

The "taking action" strategies include natural systems management choices, social systems improvements and infrastructure modifications. They allow us to manage risks effectively in the face of uncertainties. These actions generally fall into two categories. The first type relates to undertaking activities that could offset some of the negative impacts of climate change on specific resources. The second type relates to better directing management efforts and resources to locations where the actions will provide the greatest benefit. Some adaptation strategies involve doing both of these things. These types of strategies can occur at any level and do not require us to wait for federal or state governments to take action.

Implementing adaptation on a broad scale . Protecting environmentally sensitive agricultural lands by enrolling them in the Conservation Reserve Program (CRP) or similar federal or state programs could help offset some negative climate change impacts. By targeting such conservation efforts to specific areas, we can provide even greater benefits. The Coldwater Fish and Fisheries Working Group identified setting aside land in this manner as a potential adaptation strategy for coldwater streams. Maintaining native vegetation on such lands would help maintain water temperatures and prevent soil losses. The working group recommended a "triage" strategy of allocating limited resources to streams where this type of effort can delay the loss of trout. This "no regrets" strategy could help in reversing the loss of wetlands and restoring prior converted wetlands to provide storage and filtration capacity as recommended by the Water Resources and Green Bay Working Groups. This "precautionary" approach also would reduce erosion from intense rainfall events as suggested by the Soil Conservation and Stormwater Working Groups. Finally, this approach could help establish and maintain corridors of contiguous natural vegetation, an adaptation strategy identified by the Plants and Natural Communities and Green Bay Working Groups.

Adapting at the local level: building urban green infrastructure. Increasing green space in our urban communities is an adaptation strategy identified by a number of WICCI working groups. Integrating green infrastructure (open space, green roofs, tree canopy, etc.) into planning and development can reduce both stormwater runoff and heat island effects. These

actions help build resilience. As noted by the Milwaukee and Stormwater Working Groups, green infrastructure can also help reduce combined sanitary sewer overflows and prevent flooding.

To maximize the multiple potential benefits of green infrastructure, a regional perspective could facilitate cooperation among local jurisdictions. For example, Wisconsin's regional planning commissions have regional planning mandates and relatively long planning horizons:

"The Southeast Regional Planning Commission (SEWRPC) was created in 1960 to provide the basic information and planning services necessary to solve problems which transcend the corporate boundaries and fiscal capabilities of the local units of government comprising the Southeastern Wisconsin Region. For fifty years SEWRPC has provided such information and planning services needed to solve problems and provide focus and attention on key issues of regional consequence."

Building Capacity

The WICCI working groups identified a number of adaptation strategies that involve creating a better understanding of climate science, impacts and adaptation strategies along with tools for resource managers and other decision-makers. These "building capacity" strategies include conducting applied scientific research, developing local modeling and management frameworks, implementing new management techniques at the local and program level and training and educating natural resource managers and others to use new tools.

Supporting Wisconsin's State Climatologist. The Wisconsin State Climatology Office, affiliated with the UW-Madison's Department of Atmospheric and Oceanic Sciences, manages data for climate monitoring, provides climate information to Wisconsin residents and government agencies, develops "value-added" products for users and impact applications and conducts applied climate research. We recognize the

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importance of additional state funding and continued support the State Climatology Office.

A framework for local government planning. Working with the Wisconsin Towns Association, League of Wisconsin Municipalities, regional planning commissions and other local government associations, the WICCI working groups can expand efforts to help communities integrate climate adaptation strategies into local community planning activities. Communities can have greater confidence in their emergency management and hazard mitigation plans if they consider climate change impacts and the associated vulnerabilities. Similarly, land use and development plans that factor climate change scenarios into their future projections will better serve communities in guiding future development patterns. Along these lines, the Coastal Communities, Water Resources and Green Bay Working Groups suggested that communities may want to re-examine ordinances and wetland and shoreland management programs to be sure that they make sense given a likely increase in bluff recession rate, fluctuations in water levels and increasing frequency of extreme events. Communities should create or update comprehensive plans and periodically revisit and revise these plans and implement ordinances, as needed. This "precautionary" approach also could help reduce erosion

from intense rainfall events as suggested by the Soil Conservation and Stormwater Working Groups.

Short-term solutions: new species management techniques. There will always be variability in climate and climate change impacts. We can best manage variability by understanding the tradeoffs it presents. For example, fisheries managers will need to respond to changes in stream water temperatures. In warmer years, managers may want to substitute brown trout for brook trout in their stocking programs because brown trout are slightly more tolerant of warmer water. Alternatively, these managers could use a "put-and-take" approach for cold months that provides short-term angling opportunities while acknowledging that the brook trout will die off in a near-future summer.

Communicating

The WICCI working groups identified a number of adaptation strategies related to articulating the risk from future climate and the need for polices and planning that will maintain society's flexibility for adapting to new and future impacts. These "communicating" adaptation strategies include dialog with the public, decision-makers, community groups, local governments, nonprofits and others about impacts from climate change and the benefits of adaptation.

Short-term adaptations: informing the public of risks. Implementation of some strategies will result in benefits regardless of how climate changes. For example, public protection authorities (county sheriffs, conservation wardens, etc.) and weather news personnel may want to consider providing short-term risk advice on issues including thin-ice hazards on lakes or heat-related health risks.

Broad-scale adaptation: informing public officials. Working with UW-Extension, Sea Grant and other educational organizations, the WICCI working groups can expand efforts to provide local governments with information about climate science, projected impacts, types of adaptation strategies and means of implementing those strategies. Enhanced communication will be particularly important in cases where the probability of risk is low but the vulnerability is very high and "better safe than sorry" measures could significantly offset possible impacts. This could include efforts to educate communities about the hazards of building in areas prone to high water or coastal erosion, as recommended by the Coastal Communities, Water Resources and Stormwater Working Groups, or about ways to minimize sanitary sewer overflows, as noted by the Coastal Communities, Stormwater and Milwaukee Working Groups.

WHAT IS A COMPREHENSIVE PLAN?

A comprehensive plan is a local government's guide to community physical, social and economic development. Comprehensive plans are not meant to serve as land use regulations in themselves; instead, they provide a rational basis for local land use decisions with a 20-year vision for future planning and community decisions.

The Wisconsin Comprehensive Planning Law does not mandate how a local community should grow, but it requires public participation at the local level in developing a vision for the community's future. The uniqueness of individual comprehensive plans reflects community-specific and locally driven planning processes.

While a local government may choose to include additional elements, a comprehensive plan must include at least all of the nine elements below, as defined by the Comprehensive Planning Law.

- **Issues and Opportunities**
- **Housing***
- **Transportation***
- **Utilities and Community Facilities***
- **Agricultural, Natural and Cultural Resources***
- **Economic Development***
- **Intergovernmental Cooperation**
- **Land Use***
- **Implementation**

*** elements affected by climate**

Element Guides are available online at www.doa.state.wi.us.

Filling Gaps

The WICCI working groups identified a number of adaptation strategies that involve expanding our knowledge about how natural and human systems will respond to climate change. "Filling gaps" includes basic scientific research, establishing data-gathering programs, improving climate modeling and learning from climate adaptation efforts in other states. While much of this work will fall to the University and state agencies, there is room for many other players to be involved in defining information needs and helping ensure that research and monitoring improve our ability to assess risk and proactively adapt.

WICCI's next report. In this report the working groups assessed vulnerabilities and suggested adaptation strategies using currently available information and resources. An important part of filling the gaps will be recruiting additional participants for WICCI working groups to respond to emerging knowledge that results from ongoing research and new scientific discoveries. Additional working groups will be needed to address new focus areas. We expect to produce our next report in about four years.

Preparing for adaptive management: broad-scale monitoring. In order to recognize the reality of variability in climate and adapt accordingly, we will need to understand how variability manifests itself in future climate scenarios and how it is reflected in natural processes and human systems. Adaptive approaches that allow new information to be incorporated as we move forward will increase our flexibility in how we respond to changes. Along these lines, several working groups recommended instituting better, more robust climate monitoring programs. For example, the Wisconsin Department of Natural Resources and University of Wisconsin can work with federal, state and local partners (for example, the National Oceanic and Atmospheric Administration, U.S. Geological Survey, local public works and public health departments) to support a network of monitoring stations for collecting important observations. These include systems to measure rainfall, stream flows and water levels as well as surveillance programs for harmful algal blooms and beach pathogen outbreaks. As noted by the Forestry and Agriculture Working Groups, climate science that increases the certainty around precipitation trends and patterns will assist us in better impact modeling. Similarly, the Stormwater Working Group found that improving and maintaining Wisconsin's climate monitoring network would provide continued high-quality data to support short- and long-term impact modeling. The Human Health Working Group noted the importance of the Wisconsin Pubic Health Tracking Program for tracking indicators of air pollution that may be affected by climate change.

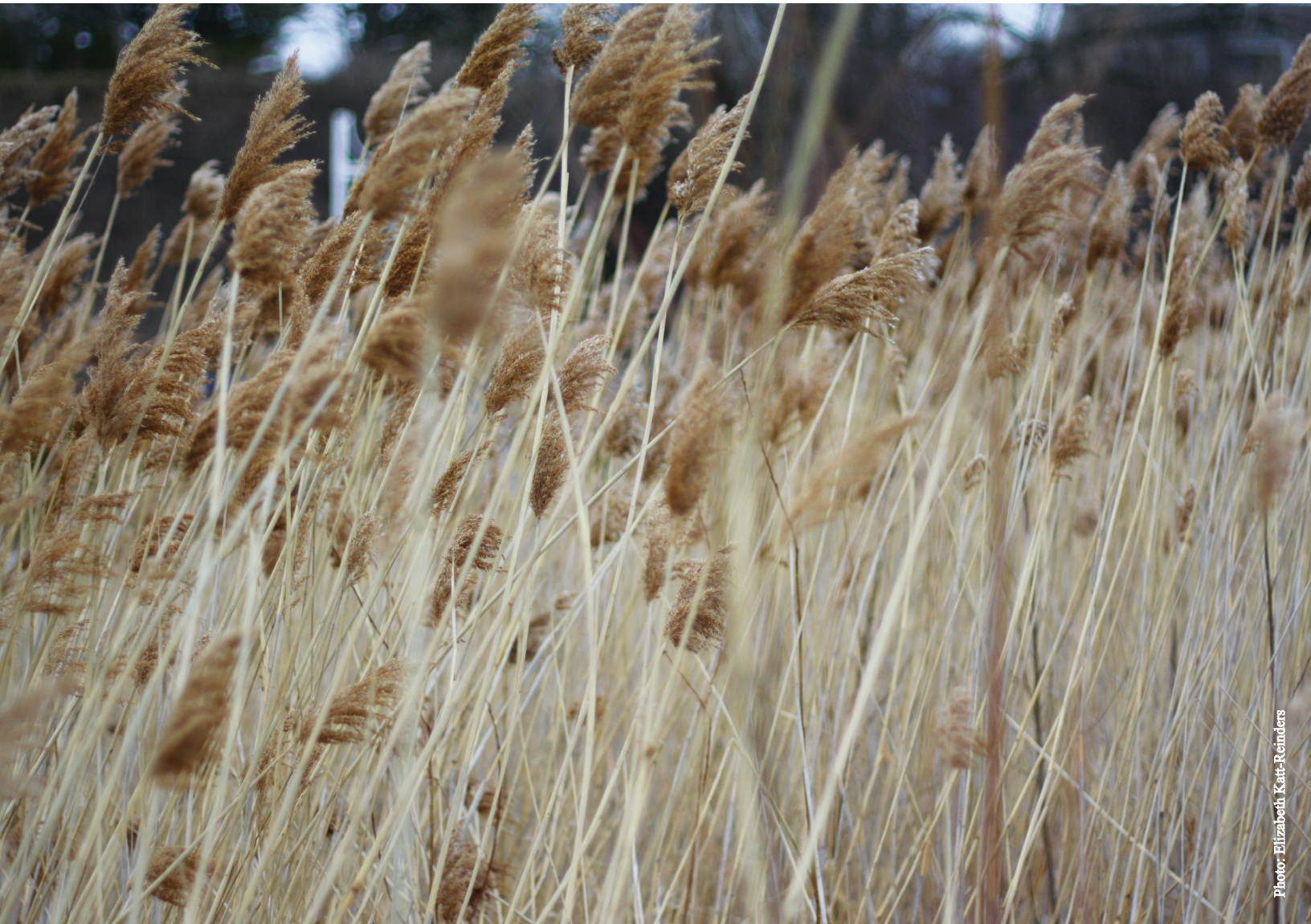
Preparing for adaptive management: species- and community-specific assessments. Resources remain insufficient to address all possible threats. To help reduce the uncertainty in making decisions about resource allocations, both the Plants and Natural Communities and Wildlife Working Groups recommended that risk assessments be made based on impact predictions for individual species and natural communities. Similarly, the Green Bay Working Group identified a number of species and community-specific information needs. These assessments could be used in prioritizing adaptation actions. As climate scientists improve global climate models and refine downscaling results, we will have more and better data on which to base such assessments.

A more complete discussion of climate adaptation can be found in the WICCI Adaptation Working Group report, available online at www.wicci.wisc.edu.

Conclusion

Climate change is a complex phenomenon with impacts on every sector of our lives. As you, the stakeholder, assess the information presented in this report and consider your options for taking action, the principles outlined in this chapter can guide your decision-making and implementation. These principles can help you consider which actions to implement first, the degree to which flexibility can be built into resource management practices and whether some strategies will bring benefits regardless of how the climate continues to change. They suggest that when vulnerability is high, it may be a better strategy to be safe rather than sorry; they remind that variability is a reality to be recognized and that some place-based impacts present unique restrictions and circumstances for adaptation. Lastly, these principles include a call for a big-picture view of adaptation, recognizing that adaptation strategies can and should be implemented alongside mitigation efforts.

This report presents a wide range of strategies for you to consider as you chart your adaptation course. You may implement these strategies to work towards a variety of goals, including taking action to confront climate impacts; building capacity for understanding climate science, impacts and adaptation; communicating the challenges and opportunities brought on by climate change; and filling the gaps in our scientific and management knowledge. This report is the first step on a long road of strategic climate adaptation in Wisconsin. The next step is yours.



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